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Integration of Global Positioning System (GPS) Information into an Emergency Locator Transmitter (ELT)

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Integration of Global Positioning System (GPS) Information into an Emergency Locator Transmitter (ELT)

by
W. Street
Northern Airborne Technology Ltd.

FEBRUARY 2001

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Un sommaire en français se trouve avant la table des matières.

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16. Abstract

Although geostationary satellites can immediately detect a 406 MHz distress signal transmitted by an Emergency Locator Transmitter (ELT), they cannot determine the location of the transmitting beacon. If Global Positioning System (GPS) information were included on the 406 MHz message, the satellites could decode the location data immediately, thus reducing the overall time required to complete a rescue operation. This report discusses two design approaches to integrating GPS technology and 406 MHz ELT technology, and presents the final design concept.

Because GPS systems are already installed on most aircraft, the advantages of downloading the aircraft's navigation data into the ELT outweigh those of integrating a GPS receiver into the ELT. These advantages include the ability to transmit position data on the first 406 MHz burst, the inherent lower installed cost, and the reduced risk of potential interference from VHF transmitters. Although navigation interface equipment is commercially available, these units are large and bulky. The navigation interface circuits must be miniaturized to fit inside the ELT.

Modifications were made to the prototype ELT electronics and mechanics to allow aircraft navigation data to be continuously downloaded via integrated navigation interface circuits in the ELT while the aircraft is in operation. This new ELT with GPS interface capabilities was submitted to the test laboratory in Toulouse, France and issued Cospas-Sarsat Type Approval Certificate #120.

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16. Résumé

Les satellites géostationnaires peuvent détecter instantanément un signal de détresse émis par une radiobalise 406 MHz, mais ils ne peuvent déterminer l'endroit d'où provient le signal. Si des données GPS étaient intégrées au signal de la radiobalise, les satellites pourraient décoder immédiatement l'emplacement de celle-ci, ce qui permettrait de réduire le temps nécessaire aux interventions de recherche-sauvetage. Ce rapport expose deux démarches conceptuelles pour l'intégration du GPS et de la radiobalise 406 MHz, et présente la démarche finalement retenue.

Comme la plupart des aéronefs sont déjà dotés d'un GPS, il est plus avantageux de télécharger les données de navigation de l'aéronef vers la radiobalise que d'incorporer à celle-ci un récepteur GPS. En effet, cette méthode permet de transmettre les données de position dès la première rafale 406 MHz, elle est relativement économique et elle présente un risque réduit d'interférence avec les transmetteurs VHF. Il existe sur le marché des dispositifs qui assurent l'interface avec le système de navigation, mais ces dispositifs sont gros et encombrants. D'où la nécessité de miniaturiser les circuits de ces interfaces pour qu'elles puissent être incorporées à la radiobalise.

Les composants électroniques et mécaniques de la radiobalise ont été modifiés de façon que les données de navigation des aéronefs puissent être téléchargées en continu vers la radiobalise, via les circuits de l'interface de navigation, pendant tout le temps où l'aéronef est en vol. Au terme d'essais au laboratoire du système Cospas-Sarsat de Toulouse, en France, cette nouvelle radiobalise à interface GPS a reçu le certificat d'homologation de type n°120 Cospas-Sarsat.

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EXECUTIVE SUMMARY

Typical detection times for a distress beacon in Canada average about two hours. The integration of location information into a 406 MHz Cospas-Sarsat beacon would combine position data and an instantaneous distress alert to be transmitted via geostationary satellites that were incorporated into the Cospas-Sarsat satellite system in 1999. This enhancement would reduce the overall time required to complete a rescue operation and increase the accuracy of the distress location.

Global Positioning System (GPS) receiver integration has already been successfully initiated in the marine sector through the development of an Emergency Position Indicating Radio Beacon (EPIRB) with an integrated GPS. For the aviation beacon, integrating a GPS receiver into the Emergency Locator Transmitter (ELT) may not be the optimal choice. It would be better to integrate a navigation interface circuit that will download location data from the aircraft's navigation system and include this data in the message of the 406 MHz distress signal that is transmitted to the satellite. Reasons for choosing this method include the ability to transmit the crash position on the first ELT burst, the inherent lower cost, and the reduced risk of potential interference from VHF transmitters.

The existing larger navigation interface units were miniaturized and included in the ELT. A bank of rotary switches under the faceplate allow for field setting of the aircraft's 24-bit address. This 24-bit address is included in the message of the 406 MHz distress signal. The electronic circuits and the housing end cap were modified to allow for the necessary mechanical and electrical interfaces.

ELTs with GPS interface circuits were fabricated, tested and submitted to the Cospas-Sarsat approved test facility in Toulouse, France. This new ELT was successfully type approved and issued Cospas-Sarsat Type Approval Certificate #120.

SOMMAIRE

Au Canada, la localisation d'une radiobalise de détresse nécessite deux heures, en moyenne. Si les données de position de l'aéronef étaient intégrées au message d'une radiobalise 406 MHz reliée au système Cospas-Sarsat, celle-ci pourrait transmettre ces données en même temps que l'alerte, via les satellites géostationnaires du système Cospas-Sarsat, créé en 1999. Un tel message «enrichi» permettrait de situer plus précisément l'aéronef en détresse et les interventions de recherche-sauvetage seraient plus rapides.

L'intégration d'un récepteur GPS a déjà été réalisée avec succès dans le secteur maritime. Ces travaux ont débouché sur une radiobalise de localisation de sinistres (EPIRB, pour *Emergency Position Indicating Radio Beacon*) à GPS intégré. Mais dans le secteur aérien, l'intégration d'un récepteur GPS à la radiobalise de détresse (ELT, pour *Emergency Locator Transmitter*) n'est pas nécessairement la meilleure solution. Il conviendrait plutôt d'intégrer à la radiobalise un circuit d'interface de navigation qui lui transmettrait les coordonnées du système de navigation de l'aéronef. Ces coordonnées seraient incorporées au message de détresse transmis par la radiobalise 406 MHz au satellite. Cette technique offre divers avantages : la position de l'aéronef en détresse est transmise avec la première rafale de la radiobalise, elle est relativement peu coûteuse et elle présente un risque moindre d'interférence avec les transmetteurs VHF.

Les chercheurs ont miniaturisé les interfaces de navigation actuelles pour les incorporer à la radiobalise. Une rangée de commutateurs rotatifs sous la plaque du boîtier permet d'entrer l'adresse à 24 bits de l'aéronef. Cette adresse fait partie du signal de détresse lancé par la radiobalise. Les circuits électroniques et le couvercle de la radiobalise ont été modifiés pour permettre l'assemblage des interfaces mécaniques et électriques nécessaires.

Des radiobalises à circuits d'interface GPS intégrés ont été fabriquées, mises à l'essai et présentées à l'installation d'essai Cospas-Sarsat à Toulouse, en France. La nouvelle radiobalise a réussi les essais et a reçu le certificat d'homologation de type Cospas-Sarsat n°120.

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GLOSSARY

ARINC	Aeronautical Radio, Inc
ASIC	Application-Specific Integrated Circuit
CMCC	Canadian Mission Control Centre
EEPROM	Electrically Erasable Programmable Read Only Memory
ELT	Emergency Transmitter Locator
EPIRB	Emergency Position Indicating Radio Beacon
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
GOES	Geosynchronous Orbiting Environmental Satellite
GPIRB™	Global Position Indicating Radio Beacon
GPS	Global Positioning System
IF	Intermediate Frequency
LED	Light Emitting Diode
LEO	Low Earth Orbiting
$LiMnO_2$	Lithium Manganese Dioxide
MCC	Mission Control Centre
PCB	Printed Circuit Board
RF	Radio Frequency
SAR	Search and Rescue
SAW	Surface Acoustical Wave
TDC	Transportation Development Centre
UHF	Ultra-High Frequency
UIN	Unique Identification Number
VCO	Voltage-Controlled Oscillator
VHF	Very High Frequency
VLSI	Very Large Scale Integration

1 INTRODUCTION

This document is the final report for the project entitled *Integration of Global Positioning System (GPS) Information into an Emergency Locator Transmitter (ELT)*, sponsored by the Transportation Development Centre (TDC).

1.1 Objectives

The objectives, as set out in the contract's Statement of Work, are as follows:

1.2 Project Objective

To integrate GPS location information into an existing 406 MHz prototype ELT to enhance the speed and effectiveness of search and rescue operations.

To obtain Cospas-Sarsat type approval certification.

1.3 R&D Objective

To develop expertise, techniques and equipment to improve flight safety in the Canadian air transportation system.

1.4 R&D Sub-objective

To conduct research and develop techniques and equipment to improve accident survivability.

1.5 Background

Due to the low altitude polar orbit and the number of search and rescue Cospas-Sarsat satellites now in space, a beacon alert

message can take anywhere from 30 minutes to 5 hours to be initially detected by the ground station. Typical detection times for Canada average about 2 hours. In 1999, geostationary satellites, which can immediately detect a 406 MHz signal, were officially included in the existing Cospas-Sarsat satellite system. The integration of GPS location information into a 406 MHz Cospas-Sarsat beacon would combine location coordinates and an instantaneous distress alert to be transmitted via the geostationsary satellites thus reducing the overall time required to complete a rescue operation.

GPS receiver integration has already been initiated in the marine sector through the development of a GPIRB, and this technology could be applied to aviation's 406 MHz ELT. The aviation community has been slow to adopt the new 406 MHz technology, mainly because of the large installed base of the older 121.5 MHz units. The successful completion of this project will introduce the advantages of this newer technology to the aviation community.

1.6 Scope

This report discusses two design approaches to combine GPS technology and 406 MHz ELT technology, and presents the final design concept.

2 WORK UNDERTAKEN AND RESULTS ACHIEVED

Including GPS data in the message of the 406 MHz distress signal would significantly reduce the search area of a distress site. The typical location accuracy achieved through the Doppler location data from the Cospas-Sarsat LEO satellites is about 2 km. The location accuracy of the GPS location data is approximately 100 m. This represents a 400:1 decrease in the search area.

2.1 Conceptual Design

At the conceptual design phase, two design approaches were considered. The first was to integrate a GPS receiver into the ELT and the second was to include an interface to allow GPS data from the aircraft's navigation system to be downloaded into the ELT.

When GPS receivers started to become popular, the receivers were physically large and costly, current consumption was high, and the lockup times were quite long. It was more time and cost efficient to interface to the existing aviation navigation system available on the aircraft. Today's GPS receivers are small and feature low costs, low power consumption and very short lockup times. It is not as clear now whether to integrate a GPS receiver into an ELT or use an interface to accept GPS data from the aircraft's navigation system. Some advantages and disadvantages for both approaches are presented in Sections 2.1.1 through 2.1.4.

2.1.1 GPS Receiver Integration Advantages

The ELT with an integrated GPS receiver is a self-contained unit with no external interfacing required except for the remote switch to the cockpit. This is a significant advantage as it simplifies installation. The integrated GPS receiver would be a major marketing feature.

2.1.2 GPS Receiver Integration Disadvantages

2.1.2.1 Time to First Position Fix

When a plane crashes and the beacon is activated, the GPS receiver requires a few minutes before location data is available, assuming that after the crash the GPS antenna still has a good view of the sky for the GPS receiver to receive signals from the GPS satellites. Situations have previously occurred where an aircraft has crashed and the beacon has activated, transmitting only one burst before apparently being consumed by fire or sinking. With the integration approach, the beacon position would not be transmitted on the first burst because the GPS engine would not have had enough time to acquire location data.

2.1.2.2 Interference

Because it would not make sense to have separate VHF/UHF and GPS antennas (duplicate costs and logistics of putting additional holes in the aircraft's skin are major drawbacks), the integrated GPS receiver approach would need to feature a combined VHF/UHF/GPS antenna. This would, however, present a potential interference problem. The harmonics of the VHF transmissions from the beacon could fall into the passband of the GPS receiver, thus jamming the already very low level signals from the GPS satellites. With 121.5 MHz and sometimes 243 MHz transmitters operating from antennas in the same structure as the GPS antenna, interference is a potential problem that may be very difficult to overcome.

2.1.2.3 GPS Receiver Environmental Requirements

The ELT has very demanding environmental requirements and a crashworthy specification that is more severe than other avionics equipment. Any GPS receiver integrated into an ELT would be required to meet all of the demanding crash survivability requirements.

2.1.2.4 Cost

The integration approach would cost significantly more than the interface approach because of the additional costs of the GPS receiver and integrated VHF/UHF/GPS antenna.

2.1.3 Data Interfacing Advantages

2.1.3.1 Continuous Position Data

The position data can be continually updated up to once a second while the aircraft is in use, depending on the navigation system. The continually updated data is stored in memory on the microprocessor chip that is powered by the aircraft's electrical system. If the aircraft crashes, the beacon will activate and the last known position will be transmitted on the first 406 MHz burst and received by the geostationary satellites, thus creating an instantaneous alert with location data.

2.1.3.2 Coding

A potential interface option would allow the ELT to be interrogated upon installation. If the 24-bit aircraft address is incorrect in the ELT, the correct address can be automatically programmed by the interface electronics. This is a very important consideration in fleet installations when a commercial airliner, full of passengers, might be delayed because a defective ELT must be replaced. In this case, a new ELT could be installed without requiring manual programming of the 24-bit address.

2.1.3.3 Interference

The aircraft navigation system antenna is typically mounted on the front section of the aircraft. The ELT antenna is typically mounted on the rear section of the aircraft. This separation will inherently assist in reducing any potential interference between the ELT transmitter and the navigation system.

2.1.4 Data Interfacing Disadvantages

2.1.4.1 Physical Interface

The main disadvantage to the interfacing approach is the need to physically connect the ELT to the aircraft navigation system and the aircraft electrical system.

2.1.4.2 Position Update

The likelihood of the navigational system surviving a crash and remaining intact is very small. The location data transmitted by the

ELT would be the last known position of the aircraft prior to the navigation system or the interface being damaged.

2.1.5 Discussion

When the advantages and disadvantages of integration and interfacing are compared, it would appear that the interfacing approach is favoured from an operational point of view as well as from a cost perspective. Although it is highly desirable to technically prove that the integration approach is possible, it does not make sense from a business point of view. Extreme pressure is mounting from all sides to reduce the cost of ELTs. Integrating a GPS receiver and using an integrated VHF/UHF/GPS antenna would increase the material costs by a considerable amount.

The current, commercially available navigation interface units required to communicate between the ELT and the aircraft navigation system are large and bulky. The design task is to miniaturize the existing technology so that the navigation interface circuits can be incorporated into the ELT.

2.2 Preliminary and Detailed Design

The preliminary and detailed design phases presented the detailed design for the interface concept design. Figure 1 shows a block diagram of the system.

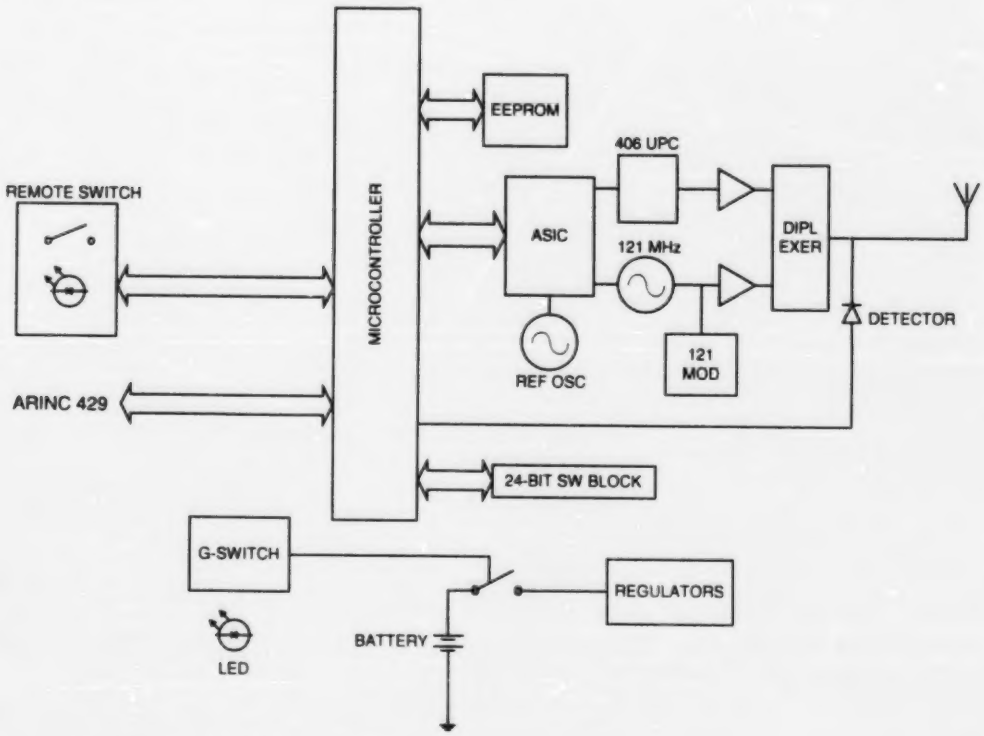

Figure 1: ELT System Block Diagram

Figure 2 shows a photograph of the modified prototype ELT developed during the course of this project.

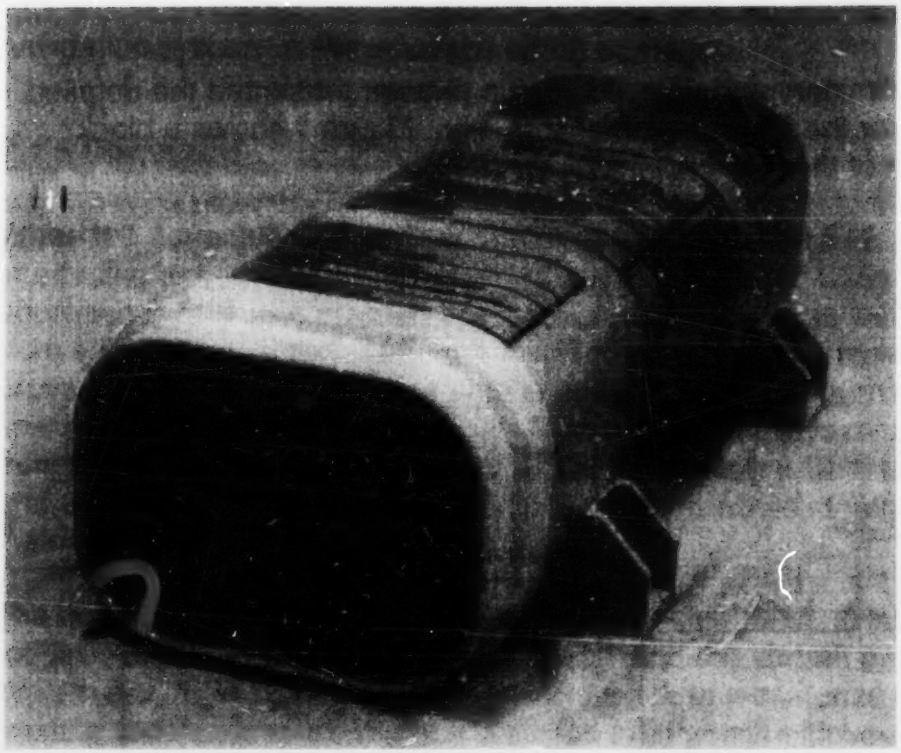

Figure 2: SATFIND-406 ELT

The ELT housing has integral mounting holes that are used to attach the ELT to the aircraft. An external dual frequency antenna is mounted on the outside of the aircraft. The remote switch is mounted in the cockpit and allows the ELT to be manually activated, manually tested or reset.

A G-switch mounted inside the ELT activates the unit when it is subjected to a certain level and direction of acceleration. When the unit is activated, a coded 406 MHz signal and a 121.5 MHz homing signal are transmitted. The 406 MHz signal contains the last update of longitude and latitude data from the aircraft's navigation system.

The 406 MHz and 121.5 MHz transmitters, the G-switch, the power latch and the system control hardware reside on one PCB, which is shown in Figure 3. The navigation interface electronics and 24-bit address switches reside on a second PCB, which is shown in Figure 4.

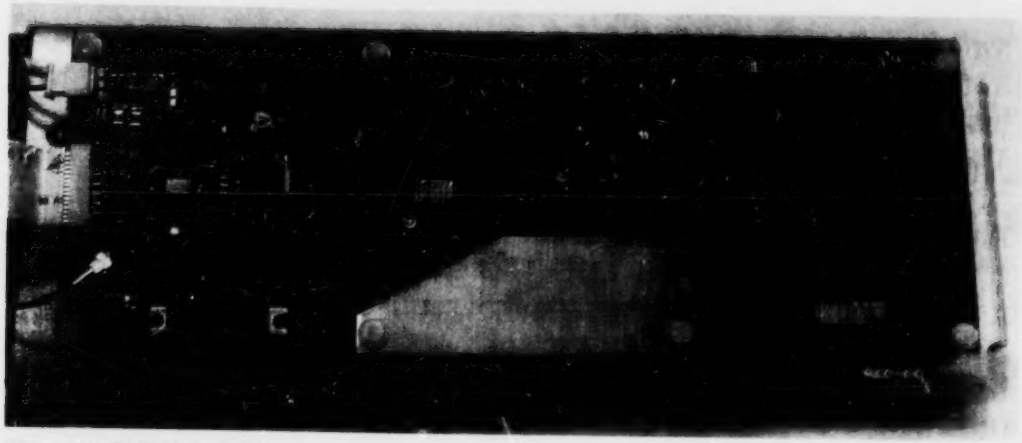

Figure 3: ELT Main PCB

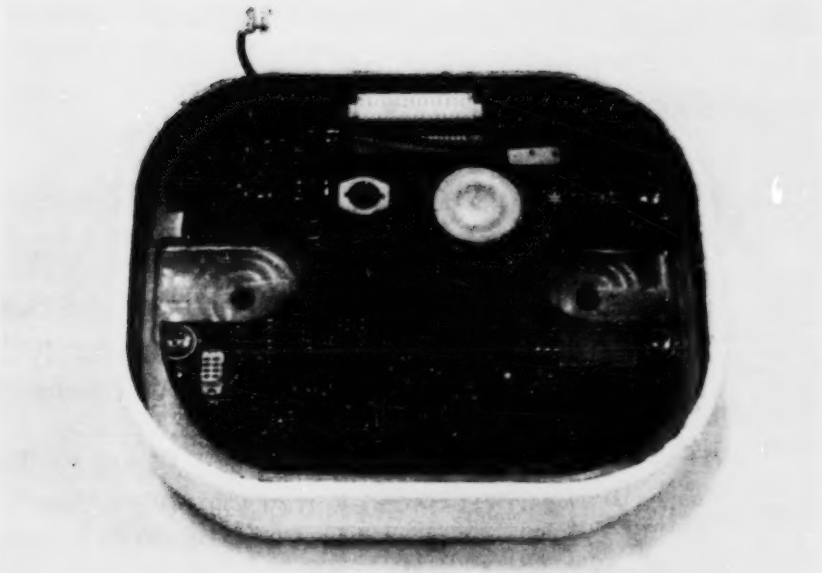

Figure 4: Navigation Interface PCB

The 24-bit address selection switches are accessible behind the removable faceplate located on the end cap, as shown in Figures 5 and 6. This enables any ELT to be easily installed into an aircraft

without requiring reprogramming at the factory. The field accessible switches are set to the aircraft's 24-bit address. After modifying the switch settings in the field, the unit would be tested using a hand-held tester that decodes and displays the transmitted 406 MHz test burst. This verifies that the switches are set correctly.

An option may be available to allow a 24-bit aircraft address switch block to be external to the ELT. This external switch block would be for the benefit of fleet operations that require quick replacement of defective units. These quick replacement ELTs would automatically be reprogrammed with the correct 24-bit aircraft address as determined by the external switch block settings. This would eliminate any possible incorrect settings made by the technician replacing the beacon. The trade-off is that more PCB real estate would be required for the protection circuitry as well as a second 24-pin connector, which would add to the cost. This option is not included in this design but may be a future consideration.

Figure 5: ELT Front View

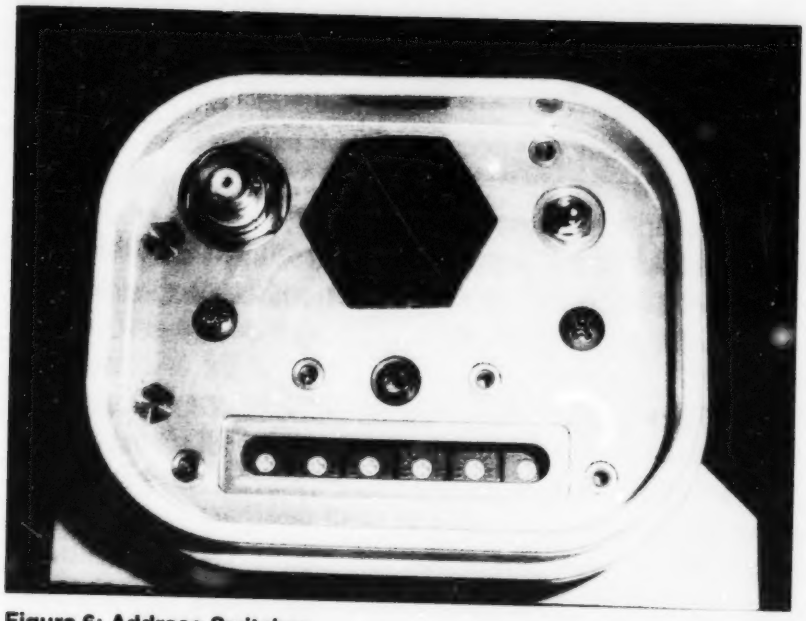

Figure 6: Address Switches

An interface cable connects the ELT, the remote switch, the aircraft's electrical supply and the navigation system. This cable is typically assembled at the installation phase, as each aircraft requirement may be unique.

2.2.1 Electrical Design

2.2.1.1 Interface Circuits

The navigation interface circuits and microprocessor circuits are powered by the aircraft's electrical system, which allows location information to be continually saved in the microprocessor's memory. When the ELT is activated, the ELT battery takes over and supplies power to the microprocessor's circuits. To prevent the loss of any stored data, a large one-farad capacitor is incorporated to compensate for any glitches when switching from the aircraft's power supply to the ELT's battery power supply.

The navigation interface assembly converts an ARINC 429 navigation signal to valid location data used by the microprocessor. Additionally, this sub-assembly provides the capability to reprogram the ELT with a unique 24-bit code should the navigation interface assembly

determine that the 24-bit address switches have changed since the last power-up.

After aircraft power-up, the ELT reads the 24-bit switch settings. If all bits are high or low, no attempt is made to re-program the ELT. Otherwise, the ELT compares this input against the 24-bit code programmed into it. If the 24-bit code received from the ELT is not the same as the 24-bit switch settings, the ELT will re-program its EEPROM to the new 24-bit address.

After 24-bit verification, the ELT main microprocessor tests the hardware and initializes the I/O ports, the timers and all variables. It validates the stored serial number as well as other data, if present, and then initializes the operating mode.

The ELT then begins actively receiving ARINC 429 GPS location data, which is serially transmitted to the ELT. Formatted position information will only be updated if both latitude and longitude ARINC words received by the ELT pass parity checks, and both latitude and longitude Sign Status Matrix bits are normal. If the ELT detects valid location information, the data is processed and stored in EEPROM locations for use in the event of an emergency.

An additional role of the microprocessor is to interface between the G-switch circuit, the activation switches, the output drivers and the ASIC. The microprocessor writes the correctly formatted message to the EEPROM in order for the ASIC to read the EEPROM when required. The message is then included on the 406 MHz burst. The microprocessor circuits are continuously powered from the aircraft's electrical system in order to receive and store location data as it is received. While the aircraft is in operation, the location information update rate is as high as once per second.

2.2.1.2 406 MHz Transmitter Section

In this new ELT, the VLSI chip is used for the generation of the digitally derived phase-modulated 10.15 MHz signal, which is upconverted to 406 MHz. It also regulates the timing for the shutdown of the 121.5 MHz transmitter. Bench test modes are used for testing during manufacturing.

The stability of the system is derived from the highly stable reference oscillator. This is a manufactured 5.075 MHz ovenized crystal oscillator. This oscillator must meet the demanding stability and thermal shock requirements set out in the Cospas-Sarsat specifications.

The phase-modulated 10.15 MHz IF output from the VLSI chip is filtered with a reconstruction filter. This signal is fed to an active mixer. The active mixer is used primarily because of the broadband terminations that are presented at each port. The local oscillator for the mixer is a 416.175 MHz VCO that is phase locked to the reference 5.075 MHz reference oscillator. The lower sideband is selected and the unwanted mixing components are filtered using the SAW filter. The SAW filter is a low-loss filter with excellent rejection characteristics outside the passband. The SAW filter requires a simple, two element matching network at both ports. An amplifier is placed after the SAW filter to provide the necessary input level to the power amplifier. A hybrid power amplifier module is used to provide the nominal 5 W output to the antenna.

2.2.1.3 121.5 MHz Transmitter Section

The 121.5 MHz transmitter is comprised of a crystal oscillator followed by a buffer stage, modulation stage, power stage and a filter.

The oscillator is a modified Pierce oscillator followed by a common base stage buffer. The low impedance of this stage acts as the emitter bypass on the oscillator, which ensures high isolation at the collector of the buffer stage. This is important to prevent the oscillator pulling while modulating the following stage. The modulation consists of a swept audio signal that sweeps downward from approximately 1300 Hz to 400 Hz. This signal is generated in a discrete circuit section and fed to the modulation stage following a buffer stage.

The modulated 121.5 MHz signal is fed to a class C output stage. The input to the class C stage is matched to the output of the modulation stage. The collector circuit is tuned to 121.5 MHz. A low pass filter at the output reduces the level of the harmonics at the output.

The level of the 121.5 MHz transmitter is 200 mW. This high level allows for the use of an antenna that is optimized at 406 MHz and may be somewhat inefficient at 121.5 MHz. This level is selected by what can be tolerated in the power budget for the chosen power source.

2.2.1.4 Diplexer

A diplexer consisting of passive fixed-value elements is used to combine the outputs of the 406 MHz transmitter and the 121.5 MHz transmitter into a single output. This output feeds the dual frequency antenna.

2.2.1.5 Battery

The battery chosen for this ELT is a 4 D-cell battery pack utilizing $LiMnO_2$ cells. This chemistry has excellent power density at -20°C. The 406 MHz transmitter must operate for a minimum duration of 24 hours and the 121.5 MHz transmitter must operate for a minimum of 50 hours at -20°C.

The power budget must address two issues: the total power consumption for operating the equipment in a worst-case situation (-20°C); and the power consumed due to self-test over 5 years.

The power budget for the ELT is shown in Table 1:

Table 1: ELT Power Budget

FUNCTION	BURST CURRENT (A)	CONTINUOUS CURRENT <24 h (A)	CONTINUOUS CURRENT >24 h (A)
406 MHz TX	2.20	0.007	0
REF OSC		0.042	0
121.5 MHz TX		0.080	0.08
Interface Circuits		0.010	0.01
TOTAL	**2.20**	**0.139**	**0.09**

The total burst current has a 1 percent duty cycle:

$$2.20\ A \times 1\% = 0.022\ A$$

Thus the total effective continuous current (under 24 hours) is:

$$0.022\ A + 0.139\ A = 0.161\ A,$$

and the total continuous current after 24 hours is 0.09 A.

The capacity of an $LiMnO_2$ D-cell is 10 A·h. The estimated storage loss over 5 years is 10 percent. The temperature derating to -20°C is ~10 percent. Thus:

$$10\ A{\cdot}h \times 90\% \times 90\% = 8.100\ A{\cdot}h$$

Each self-test decreases the battery capacity by ~0.0008 A·h. In a 5-year period there will be 60 self-tests resulting in a total decrease of 0.048 A·h.

Thus, after 5 years of being tested monthly, the battery capacity available to operate the ELT is:

$$8.100\ A{\cdot}h - 0.048\ A{\cdot}h = 8.052\ A{\cdot}h$$

The available battery capacity at 24 hours is determined:

$$8.052\ A{\cdot}h - (0.161\ A \times 24\ h) = 4.188\ A{\cdot}h$$

The operating period after 24 hours is determined by taking the available battery capacity at 24 hours and dividing by the current consumption for the remainder of the activation period.

$$4.188\ A{\cdot}h \div 0.09\ A = 46.5\ h$$

Thus, the total operating time for the ELT is:

$$24\ h + 46.5\ h = 70.5\ h$$

This represents a 41 percent margin over the specified requirement.

2.2.1.6 Remote Switch

The remote switch is a self-contained assembly that provides the switching function to activate, test or reset the ELT. An LED indicates when the unit is active and provides self-test feedback. The remote

switch is a commercially available unit that is small and easily incorporated into a cockpit. The prototype ELT was modified to allow the use of this remote switch shown Figure 7.

Figure 7: Remote Switch

2.2.1.7 Antenna

The remote antenna, a dual frequency, single port antenna that provides a 50Ω impedance at both 406 MHz and 121.5 MHz, is mounted on the outside of the aircraft and connected to the ELT by means of a short section of 50Ω coaxial cable. Figure 8 shows the antenna.

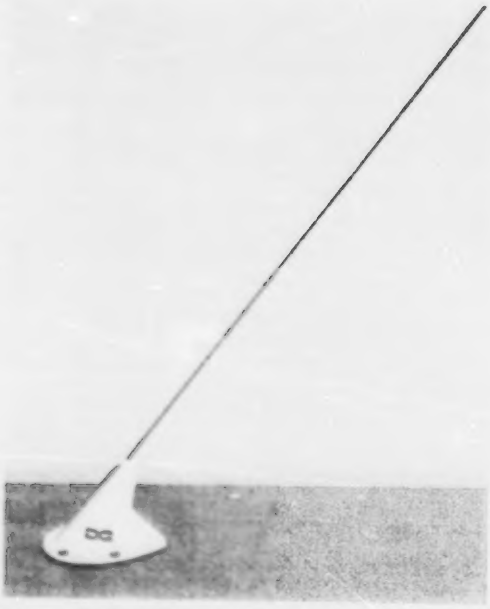

Figure 8: ELT Remote Antenna

2.2.2 Mechanical Design

The overall mechanical design concept is similar to previous prototype units. Modifications were made to the housing end cap, labels and faceplate. A discussion on the mechanical concept is presented in Section 2.2.2.1.

2.2.2.1 ELT Housing

The ELT housing was machined out of a block of Aluminum 6061-T6 in three pieces for the main enclosure and one piece for the end cap. The three main enclosure pieces were welded with full penetration welds and then re-annealed to T6 hardness as welding softens the aluminum near the weld area. The walls of the main enclosure have a nominal 0.125" wall thickness. Figure 9 shows the ELT housing with its integral mounting bracket.

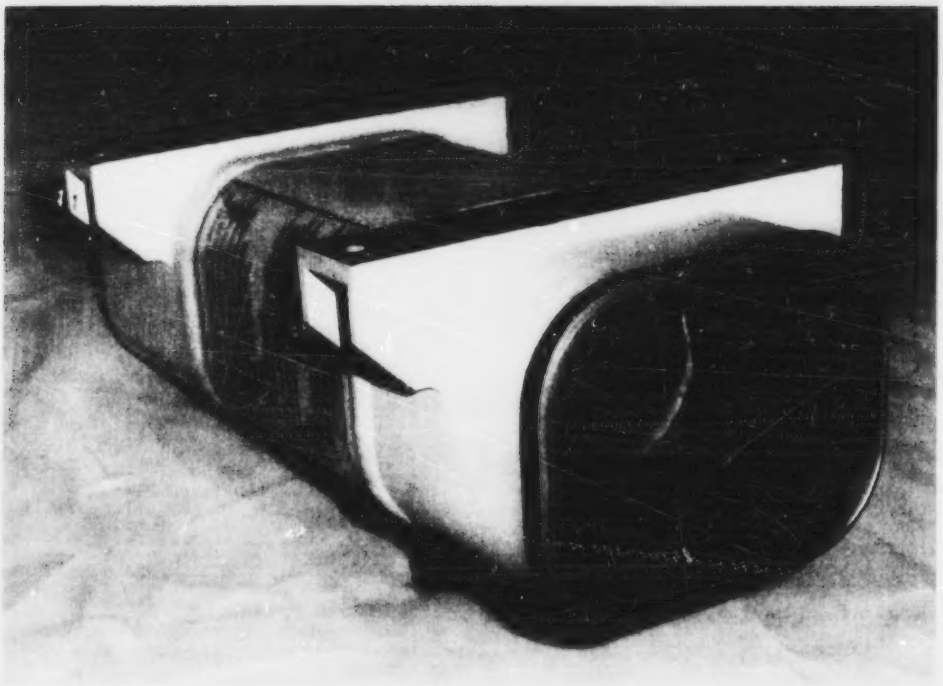

Figure 9: ELT Housing

The battery retainer was formed out of 0.093" Aluminum 6061. The battery retainer secures the battery pack to the support inside the unit. Figure 10 shows the battery secured by the battery retainer.

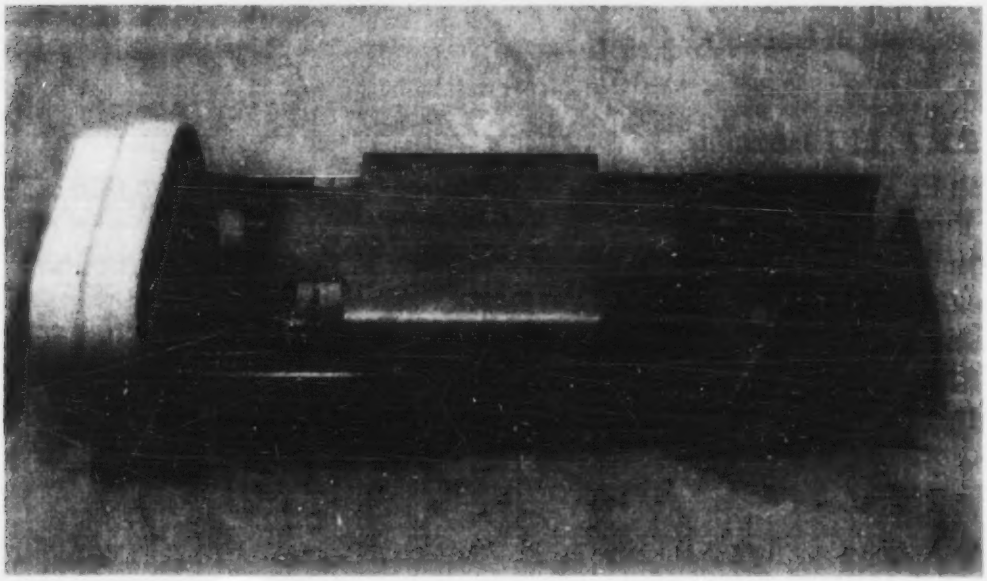

Figure 10: Battery Retainer

The water sealing of the housing is ensured through various means. The main housing attachment to the end cap is sealed using a radial compression diameter o-ring. The five screws attaching the Navigation Interface PCB to the front panel and the two screws attaching the frame to the front panel are sealed with o-ring rubber washers. The RF connector and Interface connector are sealed using a compression gasket. The LED is sealed using a clear plastic cover. Additionally, splash sealing is provided over the toggle switch using rubber boots.

The rear of the main enclosure is sealed against water intrusion. Two screws attaching the frame to the back panel are sealed using Parker Lock-O-Seal washers and o-ring rubber washers. The Parker washers are a combination outer steel/inner rubber washer.

The outside of the ELT housing is painted with yellow epoxy-type paint matching Canadian Government Specification Board No. 505-110. Prior to painting, the outside surface at the o-ring is masked.

The nameplate label on top of the unit, the operating instructions label on the right side of the unit and the battery information label on the left side of the unit are in English and French. All of these labels are in clear plastic with black printing.

2.2.3 Type Approval

The ELT with GPS interface was submitted to the Cospas-Sarsat approved test laboratory in Toulouse, France for type approval testing in accordance with *C/S T.007 Cospas-Sarsat 406 MHz Distress Beacon Type Approval Standard*. Testing was successfully completed in the fall of 2000 and Cospas-Sarsat Type Approval Certificate No. 120, as shown in Figure 11, was issued.

COSPAS SARSAT

COSPAS-SARSAT
TYPE APPROVAL CERTIFICATE

For a 406 Megahertz Distress Beacon
for use with the Cospas-Sarsat Satellite System

WHEREAS, Northern Airborne Technology Ltd., of Kelowna, B.C., Canada, the manufacturer of a 406 Megahertz Distress Beacon packaged as an ELT, and identified as Model: A 1500 SATFIND-406 ELT* has submitted test data and had said beacon tested in July 2000 at a facility accepted by Cospas-Sarsat at Intespace, Toulouse, France, to demonstrate that said beacon meets the applicable technical requirements for use with the Cospas-Sarsat Satellite System, as defined in documents C/S T.001, Issue 3 - Rev. 3, October 1999, and C/S T.007 "Cospas-Sarsat 406 MHz Distress Beacon Type Approval Standard", Issue 3 - Rev. 6 October 1999,** for frequency channel 406.025 MHz;

WHEREAS, the Cospas-Sarsat Council has determined, following a review of the test results, that the said beacon meets the Cospas-Sarsat Class 2 requirements and is rated for operating over the temperature range of -20 °C to +55 °C;*** with battery

Blue Star 95-0590
Lithium Manganese Dioxide ($LiMnO_2$), 4 D-cells LM3355)

and

WHEREAS, said manufacturer has certified that all other units of the same type will meet said technical requirements in a similar manner to the unit subjected to test, which incorporated the following features:

- *121.5 MHz Auxiliary radio locating device (23 dBm, continuous)*
- *External navigation device (GPS)*
- *Self-test mode (one burst of 520 ms, format flag bit = "1")*
- *Automatic activation (G-Switch)*

* [illegible]
** [illegible]
*** [illegible]

NOW, THEREFORE, in reliance upon the following, the Cospas-Sarsat Council does hereby certify that the 406 MHz Distress Beacon Model identified herein is compatible with the Cospas-Sarsat System as of the date of this Certificate.

Certificate No. 120

Date: 27 September 2000

Signed by:

D. Lewayne
Head of Cospas-Sarsat Secretariat

NOTE, HOWEVER:

1. This certificate does not authorize the operation or sale of any 406 MHz distress beacon. Such authorization may require type acceptance by national administrations in countries where the beacon will be distributed, and may also be subject to national licensing requirements.

2. This certificate is intended only as a formal notification to the above identified manufacturer that the Cospas-Sarsat Council has determined, on the basis of test data of a beacon submitted by the manufacturer, that 406 MHz distress beacons of the type identified herein meet the standards for use with the Cospas-Sarsat System. This certificate is not a warranty and Cospas-Sarsat hereby expressly disclaims any and all liability arising out of or in connection with the issuance, use, or misuse of this certificate.

3. This certificate is subject to revocation by the Cospas-Sarsat Council should the beacon type for which it is issued cease to meet the Cospas-Sarsat specifications. A new certificate may be issued after satisfactory corrective action has been taken and proper performance demonstrated in accordance with the Cospas-Sarsat Type Approval Standard.

Figure 11: Cospas-Sarsat Type Approval Certificate

3 CONCLUSIONS

Although GPS receivers have been successfully integrated into marine beacons, given the disadvantages of integrating a GPS receiver into a 406 MHz ELT combined with the advantages of connecting the ELT to the aircraft's navigation system and continually downloading location data, the clear choice was to proceed with the design of an ELT with an integrated GPS interface circuit.

The main reasons for choosing the interfacing approach instead of the integrating approach were the capacity to continually update position data, the ability to transmit the crash position on the first ELT burst, the inherent lower cost, and the reduced risk of potential interference from the VHF transmitters. Because commercially available navigation interface units are large and bulky, this project miniaturized the navigation interface so that it could reside inside the ELT. Six rotary hex switches were located behind a removable faceplate on the ELT, for setting or modifying the aircraft's 24-bit address in the field. Modifications were made to the ELT electronics to allow aircraft location data to be downloaded continually via the navigation interface circuits while the aircraft is in operation.

This new ELT with GPS interface capabilities was submitted to the test laboratory in Toulouse, France, for Cospas-Sarsat type approval and, after having successfully completed testing, Cospas-Sarsat Type Approval Certificate #120 was issued. Upon activation, this new ELT will produce an instantaneous alert with location data, which will result in a 400:1 reduced search area. With this drastically reduced search area, search and rescue teams can virtually fly directly to a distress site. Furthermore, the distress location will be included on the first transmission to the satellite, which will allow SAR forces to be deployed immediately, saving an average of two hours, reducing SAR costs and ultimately saving more lives.

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